WESTON
MODEL 329
POLYPHASE
WATTMETERS

INSTRUCTION BOOK

WESTON ELECTRICAL INSTRUMENT CORP.
NEWARK, N. J.

932-417

Instructions

for the use of

Model 329 Polyphase Wattmeters

Including Connection Diagrams

Weston Electrical Instrument Corp.
Newark, N. J.

F-1056—5C—3-41 PRINTED IN THE U. S. A.

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Instructions for using Weston Polyphase Wattmeter, Model 329

THE Weston Model 329 Polyphase Wattmeter is an electrodynamometer wattmeter having two independent field coil systems and two movable coil systems which are insulated from each other but mounted on the same staff. It is virtually two single phase wattmeters, the movable systems of which are mechanically connected together to operate a single pointer over a single scale.

Its indications are based on the international volt and ampere, and are accurate for direct current and alternating current measurements, within the limits stated on the certificate accompanying the instrument.

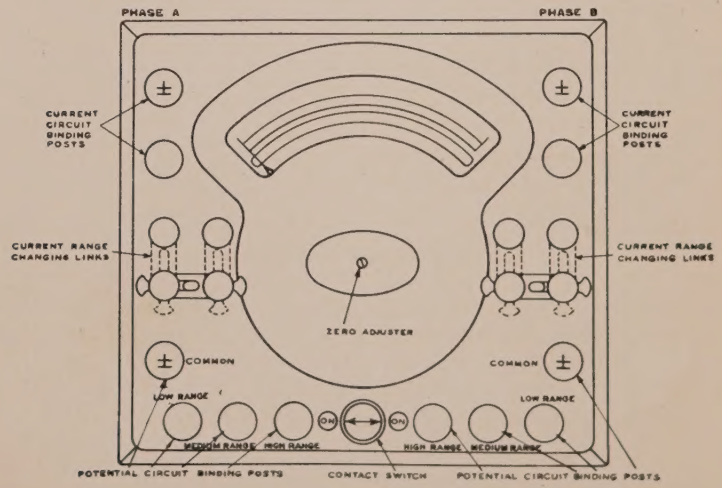

Figure 1

Arrangement of Binding Posts, Range Changing Links, etc., on the Model 329 Wattmeter.

This instrument will indicate true power on direct current and single phase alternating current two or three wire circuits. On polyphase circuits true power will be indicated on two or three phase, three wire circuits, balanced or unbalanced to any degree. On four or five wire circuits true power will be indicated on balanced circuits only.

GENERAL ARRANGEMENT OF THE INSTRUMENT

Figure 1 shows the general arrangement of the binding posts, contact switch, etc., and Figure 2 shows the relation of the internal connections to the binding posts and switch.

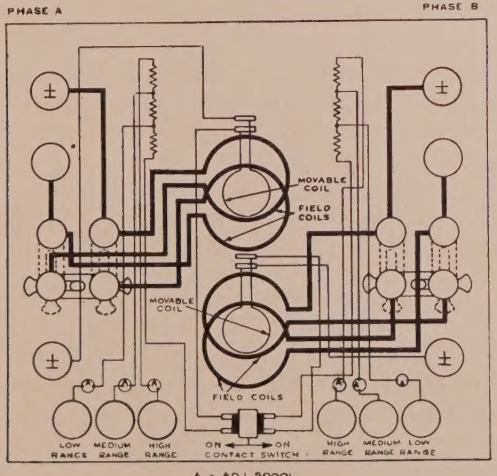

Figure 2

Internal Connections of the Model 329 Wattmeter.

NOTE:—Figs. 1 and 2: When the links are in the position indicated by full lines, the sections of the field coil are connected in series and the instrument is ready for use on the low current range. When the links are in the position indicated

by dotted lines, the sections of the field coil are connected in multiple and the instrument is ready for use on the high current range.

It is very important that the links should be tightly screwed in place, otherwise one section of the current circuit may carry more current than the other section and become heated when using the instrument at its full rated current capacity.

SHIELDING The instrument is shielded from the effect of external magnetic fields by means of a double iron shield. The two systems are also shielded from each other so that the influence of one system on the other is made negligibly small.

When using the instrument on direct current, if it is desired to obtain the greatest accuracy the mean of reversed readings should be taken to eliminate the effect of any slight residual magnetism in the shield, which may have been produced by exposure to strong magnetic fields.

To take reversed readings the connections to both the current and potential circuits must be reversed.

ZERO ADJUSTER A zero adjuster is provided to set the pointer on zero when no connection is made to the instrument. If the pointer is off zero it should not be reset until the scale glass has been discharged of all static by breathing upon it. If a zero correction of more than 5 per cent, in terms of full scale, is necessary, set the pointer to zero but check balance as well. An abnormal zero shift may be due to a bent pointer.

CONTACT SWITCH A contact switch, shown in Figs. 1 and 2, is provided for simultaneously opening or closing the potential circuit of both phases of the instrument. To obtain an indication on the instrument the switch

is turned so that the arrow on the switch knob points to the word "On."

RANGES In general the instrument has two current and three potential ranges which are self-contained. The current ranges are changed by means of links which connect the two sections of the field coils in series or in multiple (see certificate). The potential ranges are changed by making the connections to individual binding posts.

EXTENSION OF RANGES If the instrument has current ranges of 5 amperes, it can be used with current transformers to extend these ranges.

If the instrument has 125 volt potential ranges, they may be extended by the use of potential transformers or multipliers. For ranges less than 750 volts multipliers may be used, but above 750 volts both current and potential transformers are necessary.

THE SCALE The scale is drawn and figured so as to permit readings being taken with the greatest facility and accuracy. To accomplish this each scale division represents units of 1, 2 or 5 or decimal multiples of them.

In every case the factor by which the scale reading must be multiplied in order to ascertain the watts indicated is given on the certificate. Each range is provided for in this manner.

POLARITY The sign $\pm$ used in reference to the binding posts of the current and potential circuits signifies that, for either phase, the instantaneous currents entering into or passing out from these binding posts have the same direction.

OVERLOAD CAPACITY The field coils have an overload capacity of 100 percent, that is, they are capable of continuously carrying twice the normal rated current.

This is of great advantage when making measurements on circuits of low power factor.

All of the potential circuits except the highest voltage ranges have an overload capacity of about 20 percent. The actual overload capacity is stated on the certificate which accompanies the instrument. This overload capacity is convenient when it is desired to get an increased deflection (within the overload limits) for low loads or for low power factor and the current circuit cannot be arranged to accomplish this.

TEMPERATURE CORRECTIONS The instrument is in general compensated for temperature errors. If in a special instance this is not so, the factor by which the indicated watts must be multiplied to get the actual watts is given on the certificate.

PHASE ANGLE The phase displacement or shift which is usually known as the phase angle of the wattmeter is the difference between the true phase angle in the circuit under test and the apparent phase angle which enters into the wattmeter measurement. This phase shift or angle is produced in general in two ways: (1) The potential circuit has a small inductance which causes the current through it to lag behind the impressed voltage by a small angle. (2) Foucault or eddy currents are generated in the metal of the field coils and in the surrounding metal parts resulting in the magnetic field not being exactly in phase with the field coil current producing it, but lagging behind the field coil current by a small angle.

In the Model 329 Polyphase Wattmeter the phase angle has been reduced to a negligible value for frequencies as high as 125 cycles per second. This has been accomplished by making the time constant of the potential circuit so small as to be negligible and by practically eliminating the effect of Foucault

currents on the indication of the wattmeter, attained by making the metal parts surrounding the coils of a special high resistance alloy and by a proper design as to the form and location of these parts.

The importance of having the wattmeter phase angle small can be appreciated by reference to the following illustration. Suppose we have a wattmeter the phase angle of which is 10 minutes. At 95 percent power factor the error will be less than 0.1 of 1 percent, but at 20 percent power factor the error will be approximately 1.4 percent.

FREQUENCY ERRORS As stated under "Phase Angle," the indications of the instrument are independent of frequency within the limits stated on the certificate, which, for regular instruments, is 125 cycles per second.

The instruments are accurate on higher frequencies when the wave form is sinusoidal, but this conservative frequency is stated in order that the errors may be negligible when measurements are made in which the current contains harmonics of large amplitude.

CONSTANTS OF THE INSTRUMENT The resistance and inductance of the current and potential circuits for the various ranges are given on the certificate. These values will be found of use when allowing for instrument losses as hereinafter described, and for correcting for transformer errors when the instruments are used in conjunction with transformers.

Use of the Model 329 Polyphase Wattmeter

The instrument should be connected to the circuit as shown in the diagrams found at the back of this book, beginning with page 15, which cover all of the circuit conditions usually met with in practice.

Each phase of the wattmeter should be considered as an ordinary single phase wattmeter and the same procedure followed as when connecting a single phase wattmeter to the circuit. In general, connect the field or current coils in series with the load, and the potential circuit in parallel with the load. This is very clearly illustrated in Fig. 18, page 20, which shows the instrument connected to a four wire two phase circuit. Always connect the ± binding post of the potential circuit to the same side of the circuit under test which contains the current coil of the wattmeter. This should be done so as to have the current and potential coils at the same potential to eliminate the electrostatic attraction between them, which would otherwise introduce an error in the indication.

When connecting the instrument in circuit always have the links of the two phases similarly placed, and connect the potential wires to potential binding posts of like range.

By referring to any of the connecting diagrams showing the instrument connected directly to the line, it will be noted that the current to supply the potential circuit of the instrument, as well as the load current, passes through the field coils, so that the wattmeter also measures the power lost in its own potential circuits. The instrument is not compensated for this loss, but as the average value is only about 4 watts at 110 volts, a correction need not be made for it when a loss of 4 watts is negligible in comparison to the watts of the load under test.

In testing other wattmeters, if the diagrams are followed the wattmeter loss does not enter in and of course does not need to be considered.

When current and potential transformers are used, the correction for the wattmeter loss usually becomes so small as to be negligible.

In making measurements where the wattmeter loss cannot be neglected, the indications can be corrected as shown on page 14.

UTILIZATION OF OVERLOAD CAPACITY The advantage of an instrument with an overload capacity is best demonstrated by means of an example. Suppose we have a wattmeter, rated current capacities of 5 and 10 amperes, rated potential capacities of 62.5, 125 and 250 volts. The maximum capacities of this instrument are 10 and 20 amperes, 75, 150 and 300 volts respectively.

We wish to use the instrument to ascertain the power in a two phase, four wire, balanced circuit, the current being 6 amperes, voltage 110 volts, and power factor 75 percent. The load watts of each phase will be $6 \times 110 \times 0.75 = 495$ watts. The total watts as indicated on the instrument will be 990 watts. Ordinarily the 10-ampere and 125-volt ranges would be used, the watt range being 2000 watts for full scale deflection.

The indication produced by 990 watts would be a little less than half scale. Since the 5-ampere range can carry 10 amperes, this range can be used with the 6 ampere current, thus getting a deflection twice that obtained before, the full scale value now being 1000 watts. In this way it is possible to obtain more accurate readings than at a lower portion of the scale.

Numerous instances will occur in practice where the overload feature will be found of great value.

USE OF MULTIPLIER When a multiplier is used, it must be connected to the range of the instrument to which it is adjusted. As an example let us suppose we have an instrument with potential ranges of 62.5, 125 and 250 volts and a multiplier for 500 volts. The multiplier will have four

binding posts. Two of these binding posts will be marked $\frac{125\text{ V}}{1}$ and two $\frac{500\text{ V.}}{4}$ Also those corresponding to the two phases of the instrument will be marked Phase A and Phase B.

Connect the binding posts of the multiplier which are marked $\frac{125\text{ V}}{1}$ to the binding posts of the instrument marked 125, care being taken to connect to the proper phases; then connect the binding posts of the multiplier marked $\frac{500\text{ V}}{4}$ to that wire of the circuit which does not contain the current circuit of the wattmeter, again being careful to connect to the proper phases.

The marking $\frac{500\text{ V}}{4}$ means that the watts as indicated by the instrument must be multiplied by 4 to obtain the total watts when using the 500-volt range of the instrument.

Care must be taken never to connect the multiplier to the $\pm$ binding posts of the instrument as such a connection will put the full line voltage between the current and potential coils, which may cause electrostatic attraction between them, introducing errors and placing an unnecessary stress on the insulation.

ALTERNATIVE METHOD OF CONNECTION The wattmeter may be connected to the circuit as shown in Fig. 3.

In this method the potential circuits of the wattmeter are connected on the source side of the current coils and the instrument includes in its indication the power lost in the circuit between the potential circuit connection and the load; that is the loss in switches, fuses or other auxiliary apparatus as well as in the current or field coils of the wattmeter.

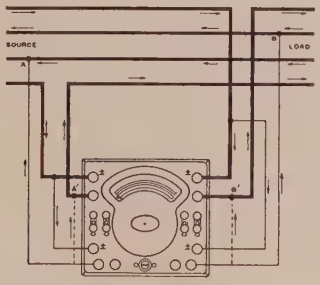

Figure 3

Connections for measuring A.C. Power in a two phase, four wire circuit, instrument connected to include in the indication the losses in its current circuits.

This method of connection possesses several disadvantages; when current transformers are used it is difficult and often impractical to allow for the losses, and in all cases the losses vary with the current and with changes in temperature so that the correction to be applied very often cannot be accurately determined.

In cases where the only loss between the wattmeter connection and the load is that of the wattmeter current circuit, the loss is usually so small that it can be neglected.

Should any circumstances arise necessitating the use of this method of connection, the wattmeter will indicate its losses by changing the potential connections from A to A′ and B to B′ in Fig. 3.

Method of Correcting for Wattmeter Losses when the Wattmeter is connected in Circuit as shown in Figs. 4 to 21, pages 15 to 22

It has been stated on page 10 that the instrument indicates the sum of the load watts and the watts loss in the wattmeter. In order to determine the actual power of the load in watts read the total watts indicated by the instrument and from this value subtract the instrument losses.

The correction to be applied for the various cases in which the instrument may be used is numerically illustrated in the following examples:

The loss in the wattmeter potential circuit at 115 volts is only about 2.1 watts and in the current circuit at normal current capacity is only about 0.7 watt. On large loads these small losses form an almost negligible part of the total reading. On small loads, however, the losses in the wattmeter, its multiplier and potential transformer may form a considerable part of the indicated load. These losses will be indicated directly by the wattmeter, when connected into circuit as shown by diagrams 4 to 21, by simply opening the load circuit on the load side of the wattmeter, its multiplier or potential transformer.

CAUTION Always connect the ± binding post of the potential circuit to the same side of the circuit under test which contains the current coil of the wattmeter. This should be done so as to have the current and potential coils at the same potential to eliminate the electrostatic attraction between them, which would otherwise introduce an error in the indication.

When current or potential transformers are used it is necessary to connect the ± binding post of the potential circuit to the ± binding post of the current circuit. When both potential and current transformers are used the connection between the ± binding posts should be grounded.

Connection Diagrams

Connections for Measuring D.C. and Single Phase A.C. Power

Current and Potential Circuits of Both Systems Connected in Multiple. Instrument Direct Reading.

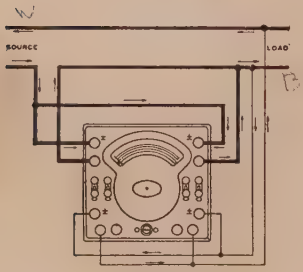

Figure 4
Connected Directly to the Load.

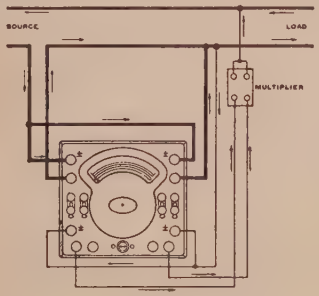

Figure 5
Connected to the Load Through a Multiplier.

Current Circuits of Both Phases Connected in Series. Potential Circuits of Both Phases Connected in Multiple. Multiply Reading by ½.

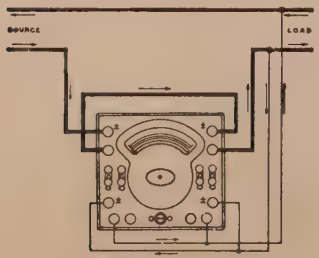

Figure 6
Connected Directly to the Load.

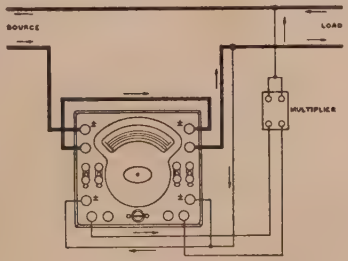

Figure 7
Connected to the Load Through a Multiplier.

Connections for Measuring Single Phase A.C. Power Using Transformers

Current and Potential Circuits of Both Systems Connected in Multiple. Instrument Direct Reading.

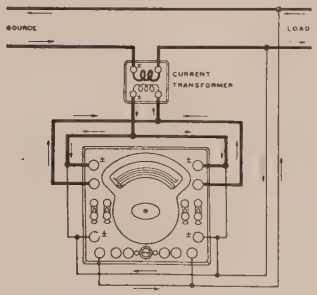

Figure 8
Connected to the Load Through a Current Transformer.

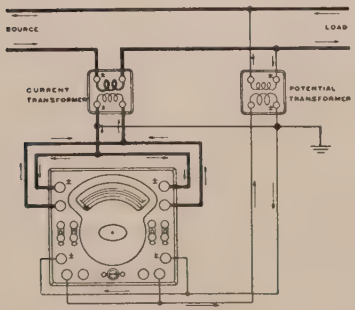

Figure 9
Connected to the Load Through Current and Potential Transformers.

See caution note on page 14.

Connections for Measuring Single Phase A.C. Power Using Transformers

Current Circuits of Both Phases Connected in Series. Potential Circuits of Both Phases Connected in Multiple. Multiply reading by ½.

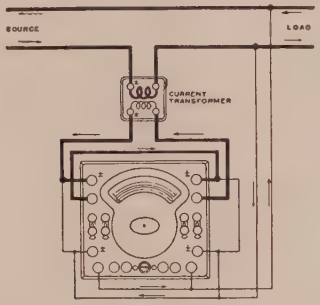

Figure 10
Connected to the Load Through a Current Transformer.

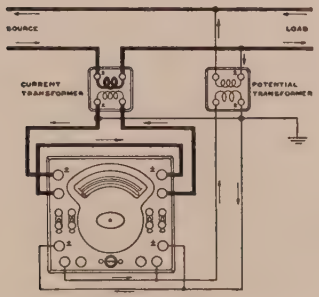

Figure 11
Connected to the Load Through Current and Potential Transformers.

See caution note on page 14.

Methods of Checking a Model 329 Wattmeter

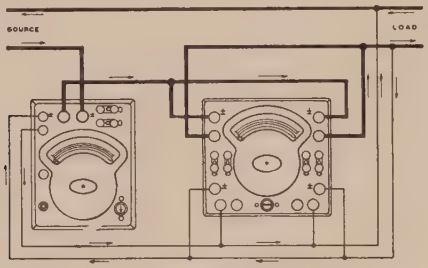

Figure 12
When Using a Model 310 Single Phase Wattmeter Either on a D.C. or an A.C. Source.

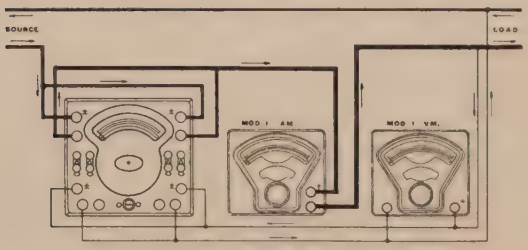

Figure 13
When Using a D.C. Ammeter and Voltmeter.

Note: Figs. 12 and 13:—It is advisable to check the systems separately as well as both together. To check the systems separately connect to one at a time according to the above diagrams. Double normal current should be used when checking a single system.

Connections for Measuring Power in D.C., Single, Two and Three Phase A.C., Three Wire Circuits

Note: Arrows do not apply when using on D.C. or Single Phase A.C. Circuit.

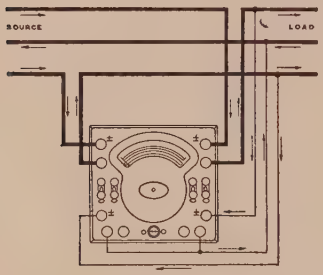

Figure 14
Connected Directly to the Load.

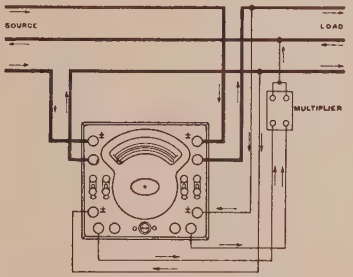

Figure 15—Connected to the Load Through a Multiplier.

Connections for Measuring Power in Single, Two and Three Phase A.C. Three Wire Circuits Using Transformers

Note: Arrows do not apply when using on Single Phase A.C. Circuit.

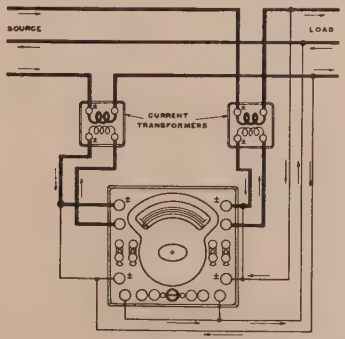

Figure 16
Connected to the Load Through Current Transformers.

See caution note on page 14.

Connections for Measuring Power in Single, Two and Three Phase A.C. Three Wire Circuits Using Transformers (Cont.)

Note: Arrows do not apply when using on Single Phase A.C. Circuit

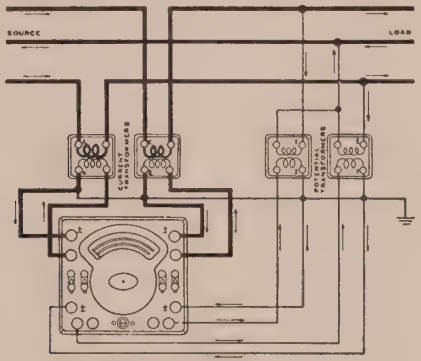

Figure 17
Connected to the Load Through Current and Potential Transformers.

Connections for Measuring Power in a Two Phase Four Wire A.C. Circuit

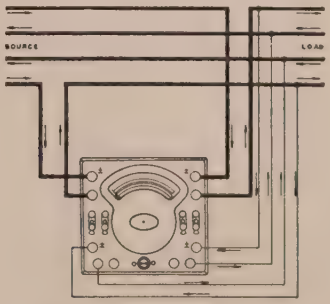

Figure 18
Connected Directly to the Load.

See caution note on page 14.

Connections for Measuring Power in a Two Phase Four Wire A.C. Circuit (Cont.)

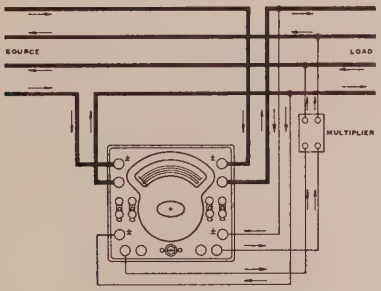

Figure 19
Connected to the Load Through a Multiplier.

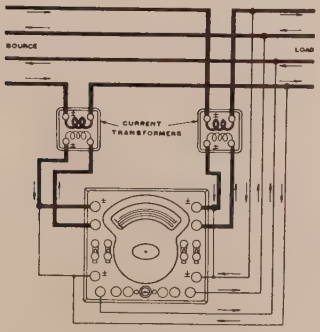

Figure 20
Connected to the Load Through Current Transformers.

See caution note on page 14.

Connections for Measuring Power in a Two Phase Four Wire A.C. Circuit (Cont.)

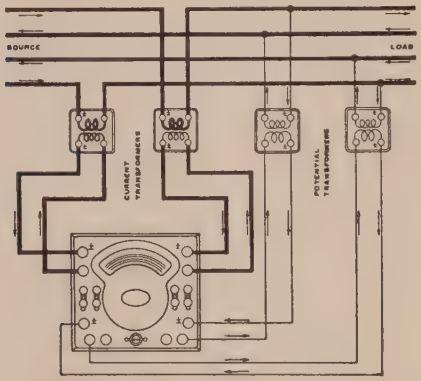

Figure 21
Connected to the Load Through Current and Potential Transformers.

See caution note on page 14.

MP MASTER
MA35453